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Philippine Currency Paper Bill Counterfeit Detection through Image Processing using Canny Edge Technology

Ballado, A. H. Jr., Dela Cruz, J. C., Avendaño, G. O., Echano, N. M., Ella, J. E., Medina, M.E.M., Paquiz, B.K.C.
School of Electrical, Electronics, and Computer Engineering
Mapúa Institute of Technology
Manila, Philippines

***Abstract*—Image edge information is essentially one of the most significant information in an image, which can describe the target outline, its relative position within the target area, and other important information. Edge detection is one of the most important process in image processing, and the detection results directly affects the image analysis. Traditional edge detection algorithms are accomplished through detecting the maximum value of the first derivative or zero crossing of the second derivative. Though it seems the representative first order differential operators have known advantages like simple computation, speed and ease of implementation, they are more sensitive to noise and their detection effect are not perfect in most engineering application. Schemes for counterfeit detection has been continuously evolving through various techniques and algorithms run on machines and devices. This paper presents image enhancement and image sensing through the use of Canny Edge Technology. Moreover, counterfeit detection on selected Philippine banknotes was achieved by incorporating a distinct security feature known as Optically Variable Device (OVD) patch, as an improvement to the traditional three-way detection of bills (watermark, security thread, see-through marks)A MATLAB GUI program was developed that acquired and processed the image through Canny Edge Technology. The Canny Edge algorithm proved a robust method in detecting fake bills through OVD security features, revealing statistically significant detection proportion under a 5% level of significant for the four cases under test.**

***Keywords* – counterfeit detection; banknotes; image processing; security feature; Canny Edge Detection; Optically Variable Device**

I. INTRODUCTION

Image edge information is essentially one of the most significant information in an image, which can describe the target outline, its relative position within the target area, and other important information. Edge detection is one of the most important process in image processing, and the detection results directly affects the image analysis.

The traditional edge detection algorithms are accomplished through detecting the maximum value of the first derivative or zero crossing of the second derivative [1]. Although the representative first order differential operators have known advantages like simple computation, speed and ease of implementation, they are more sensitive to noise and their detection effect are not perfect in engineering application.

Canny edge detector detects edges in images through multi stage algorithm. John F. Canny in his paper computational techniques in edge detection explains the process, parameters and improvements of the algorithm in the detection process. The Canny edge detection algorithm uses three criteria to judge edge detection operator' performance: SNR criterion, localization precision criterion and single edge response criterion, and deduced the Canny edge detection operator [2-3].

The Bangko Sentral ng Pilipinas (BSP) is the only government entity authorized to print, issue and distribute legal Philippine currency within its sovereign. These issued currency notes and coins continually circulate or change hands among the public. The public passes them on and utilize such as legal tender, without full knowledge if the currency is genuine. Those who fail to carefully examine the money they receive are potential victims of counterfeit currency. Moreover, it's been historically known that counterfeits proliferate in huge numbers on relevantly known occasions like holiday seasons, elections and other events where money will be massively consumed.

Several papers working on counterfeit detection have been published, reviewed and evaluated [4-10]. Image processing is the common detection approach. However, different algorithms were tried from Principal Component Analysis (PCA), Artificial Neural Networks (ANN) to Machine Visions to Support Vector Machines. All these yield credible results on addressing counterfeit concerns.

Bank notes and other security documents often incorporate optically variable devices (OVDs) such as diffraction gratings or holographic optical microstructures as security features against copy and counterfeit. The increased use of such devices has been motivated by progress in the fields of computer-based

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desktop publishing and scanning, which render conventional security print technologies, such as intaglio and offset printing, increasingly susceptible to counterfeit. One way to strengthen security documents against counterfeit is to combine security print with optically variable devices whose structures cannot be replicated by scanners, and which can exhibit optically variable effects such as color changes by diffraction, movement effects, and distinct switches between images [11].

This paper provided a mechanism to detect and verify if the Philippine peso paper bill is authentic through the verification of the security features selected by the researchers using digital image processing technique of MATLAB. Moreover, this study specifically aims to: (1) program a MATLAB GUI that will acquire and process the image through the Canny Edge Technology, (2) incorporate the optically device patch feature into the detector circuit and as an additional security feature, (3) statistically validate improvement on counterfeit detection using Canny Edge Technology, and (4) implement the three-way to the four-way detection and compare using Canny Edge Technology as applied in the design.

II. METHODOLOGY

Shown below is the block diagram of the paper bill counterfeit detection system, in Figure 1. The process starts by placing genuine money in the money box serving as the reference image for the other paper bill to be tested. User chooses peso bill denomination of money to be tested. A camera then takes one side of the money first and capture the three security features present on the right side. The user then selects each of the three security features present so that the program will save them as the reference images for testing. To check functionality, few peso bills will be placed repeatedly using similar procedures.

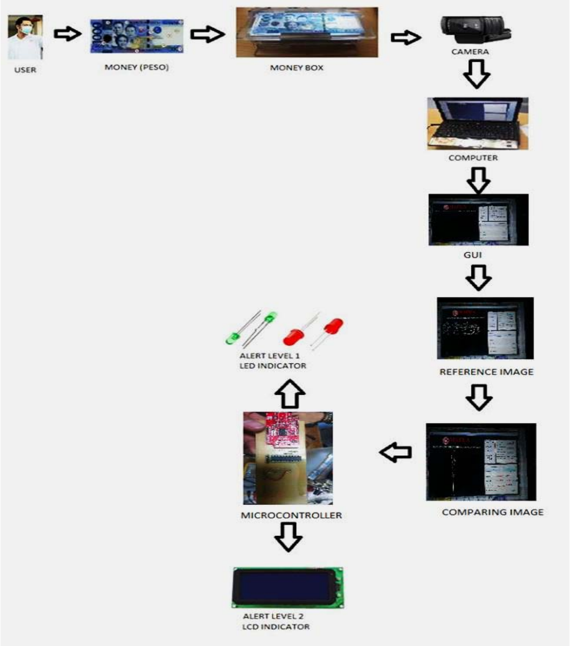


Figure 1. Design of the money counterfeit detection system

During this time, the camera captures the peso bill. Once the user press the "Compare" button of the GUI program, comparison between the paper bill under test and the reference bill will be evaluated.

A graphical user interface (GUI) was developed using MATLAB software. The GUI displays the reference and the acquired image of the security features of the Philippine peso bill to clearly visualize the differences between the two images that were acquired and processed by the program. Several trials for the different Philippine paper bills and its image were evaluated and interpreted. The microcontroller was responsible for LCD and LED indicators to display the results.

An optically variable device patch feature was incorporated into the detector circuit and added as feature. The money plate was rotated approximately 45 degrees angle, in order for the web camera to see the optical variable device patch and started image acquisition to process the captured image. On the Philippine peso bill, there was a reflective foil (oval shape) with BSP image on parrot (500 peso bill) and Pearl inside the clam (1000 peso bill). The color of the parrot and the clam changed from RED to GREEN when rotated approximately 45 degrees angle. The processor communicated to the microcontroller which served as a memory for the results. Figure 2 shows how the OVD patch of the new Philippine peso bill that was not tilted and Figure 3 and Figure 4 showed how the OVD patch of the new Philippine peso bill that is approximately 45˚tilted for the 500Php and 1000Php respectively which will be processed and analyzed in MATLAB.

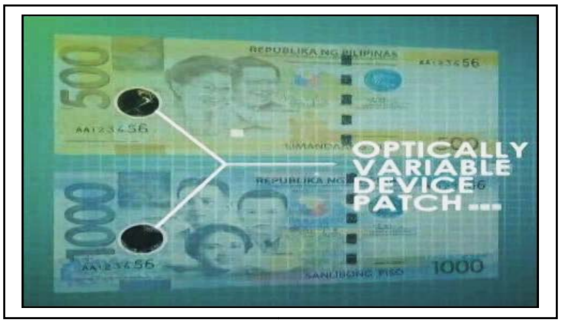


Figure 2. Optically Variable Device Patch (Not Tilted)

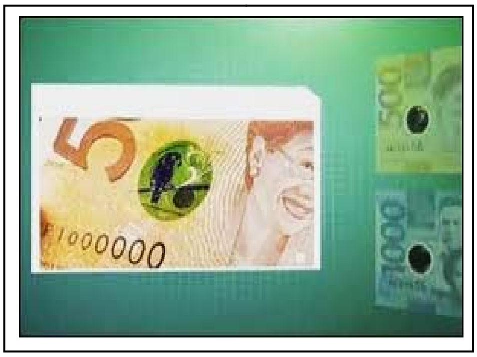


Figure 3. OVD Patch 500Php (45˚ Tilted)

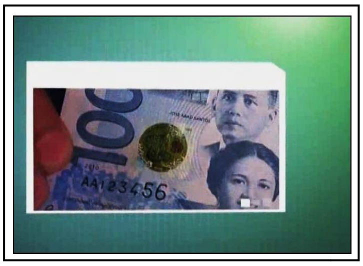


Figure 4. OVD Patch of 1000Php (45˚ Tilted)

Validating the system for significant improvement, statistical test conditions for proportion were used. The test conditions were applied on these four cases at the 5% level of significance (or a 5% type-I error). Thirty (30) various peso bills were tested.

Case I. Genuine Money detected as Genuine Money
Case II. Counterfeit Money detected as Counterfeit Money
Case III. Genuine Money detected as Counterfeit Money
Case IV. Counterfeit Money detected as Genuine Money

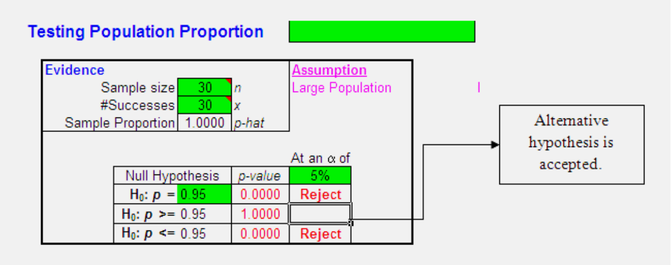
The following hypothesis were formulated:
Null hypothesis: There was no significant improvement in the image detection using the researcher's image detection algorithm compared to the reference algorithm.
Alternative hypothesis: There was a significant improvement in image detection using the researcher's image detection algorithm compared to the reference algorithm.

The 3-way to 4-way detection was compared using Canny Edge Technology. The three-way detection included the see-through marks, watermarks and security thread. The four-way detection includes see-through marks, watermarks, security thread and optically variable patch. The detections done in this section were only applicable for Php1000 and Php500 peso bills. Proponents compared the results to verify the effectiveness and the accuracy of the 4-way detection compared to the 3-way detection.

III. RESULTS AND DISCUSSION

The first null hypothesis of the study as shown in Table 1 was the proportion of successfully detecting the genuine money to be genuine (true positive) is at most 95%. At a 5% level of significance, samples under study showed that all samples under test were identified to be genuine. Using the data gathered from the 30 test subjects, the proponents have arrived to a 100% success rate. Tests result showed that null hypothesis was rejected thus, alternative hypothesis was accepted, which was the proportion of successfully detecting the genuine money to be genuine (true positive) is greater than 95%.

TABLE I. TESTING POPULATION PROPORTION FOR CASE I (GENUINE MONEY DETECTED AS GENUINE MONEY)



Testing Population Proportion

Evidence

Sample size	30	*n*
#Successes	30	*x*
Sample Proportion	1.0000	*p-hat*

Assumption
Large Population

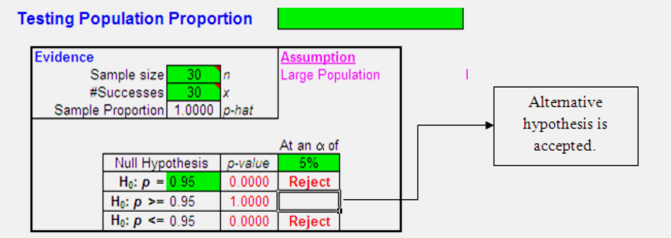
At an α of

Null Hypothesis	*p-value*	5%
H_0: *p* = 0.95	0.0000	Reject
H_0: *p* >= 0.95	1.0000	
H_0: *p* <= 0.95	0.0000	Reject

Alternative hypothesis is accepted.

The second null hypothesis of the study as shown in Table 2 was the proportion of successfully detecting the counterfeit money to be counterfeit (true negative) is at most 95%. At a 5% level of significance, samples under study showed that all samples under test were identified to be counterfeit.

TABLE II. TESTING POPULATION PROPORTION FOR CASE II (COUNTERFEIT MONEY DETECTED AS COUNTERFEIT MONEY)



Testing Population Proportion

Evidence

Sample size	30	*n*
#Successes	30	*x*
Sample Proportion	1.0000	*p-hat*

Assumption
Large Population

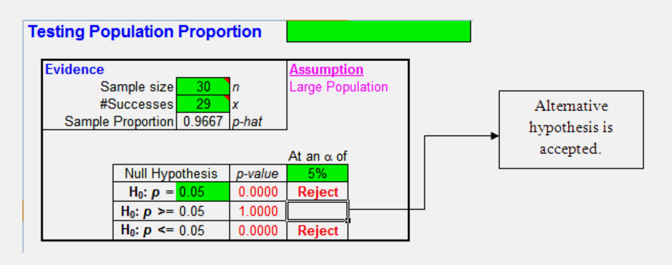
At an α of

Null Hypothesis	*p-value*	5%
H_0: *p* = 0.95	0.0000	Reject
H_0: *p* >= 0.95	1.0000	
H_0: *p* <= 0.95	0.0000	Reject

Alternative hypothesis is accepted.

The third null hypothesis of the study as shown in Table 3 was the proportion of successfully detecting the genuine money to be counterfeit (false positive) is at most 5%. At a 5% level of significance, samples under study showed that 29 out of 30 were identified to be counterfeit. Using the data gathered from the 30 test subjects, the researchers have arrived to a 96.67% success rate.

TABLE III. TESTING POPULATION PROPORTION FOR CASE III (GENUINE MONEY DETECTED AS COUNTERFEIT MONEY)



Testing Population Proportion

Evidence

Sample size	30	*n*
#Successes	29	*x*
Sample Proportion	0.9667	*p-hat*

Assumption
Large Population

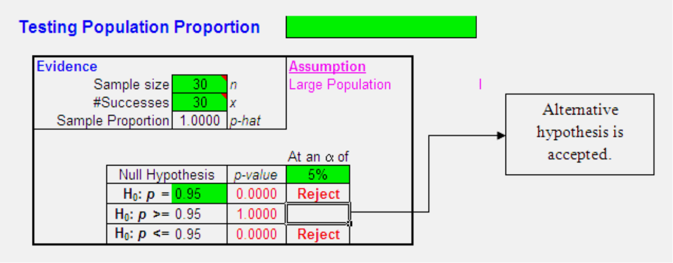
At an α of

Null Hypothesis	*p-value*	5%
H_0: *p* = 0.05	0.0000	Reject
H_0: *p* >= 0.05	1.0000	
H_0: *p* <= 0.05	0.0000	Reject

Alternative hypothesis is accepted.

The fourth null hypothesis of the study as shown in Table 4 was the proportion of successfully detecting the counterfeit money to be genuine (false negative) is at most 5%. At a 5% level of significance, samples under study showed that 30 out of 30 were identified to be genuine. Using the data gathered from the 30 test subjects, the researchers have arrived to a 100% success rate.

TABLE IV. TESTING POPULATION PROPORTION FOR CASE IV (COUNTERFEIT MONEY DETECTED AS GENUINE MONEY)



Testing Population Proportion

Evidence			Assumption
Sample size	30	*n*	Large Population
#Successes	30	*x*	
Sample Proportion	1.0000	*p-hat*	

At an α of

Null Hypothesis	*p-value*	5%
H_0: p = 0.95	0.0000	Reject
H_0: p >= 0.95	1.0000	
H_0: p <= 0.95	0.0000	Reject

Alternative hypothesis is accepted.

IV. CONCLUSION

Image enhancement and image sensing through the use of Canny Edge Technology was validated. Moreover, counterfeit detection on selected Philippine banknotes was achievedby incorporating a distinct security feature known as Optically Variable Device (OVD) patch, as an improvement to the traditional three-way detection of bills (watermark, security thread, see-through marks)

A MATLAB GUI program was developed that acquired and processed the image through Canny Edge Technology. The Canny Edge algorithm proved a robust method in detecting fake bills through OVD security features, revealing statistically significant detection proportion under a 5% level of significant for the four cases under test.

Moreover, the study was able to validate significant improvement on counterfeit detection using Canny Edge Technology. Successful implementation of the three-way to four-way detection was achieved using Canny edge algorithm.

V. RECOMMENDATION

The study can be further improved using heuristic approaches. It also recommends adding other security features in the Philippine peso bills as basis for detection. Moreover, duration of detection process may be considered and optimized.

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